Strong, Ductile and Low-Field Magnetostrictive Alloys Based on Fe-Ga

PI: Sivaraman Guruswamy, University of Utah

DMR Award # 0241603

Research Objectives

Our earlier work has shown that the addition of nonmagnetic element Ga in Fe results in an order of magnitude increase in low field magnetostriction (Change in length with applied magnetic field). FeGa alloys are also strong and ductile, and show low hysteresis.

The two major objectives of current work are

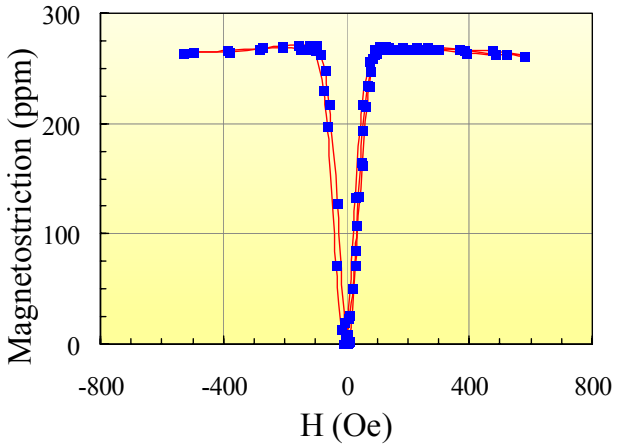
- To examine Fe-Ga based alloys and other Fe based alloys containing additions that differ from Ga in their ground state electronic structure in order to better understand the magnetostriction phenomenon
- To develop a thermomechanical processing scheme for obtaining (001) textured FeGa alloys and examine texture evolution during processing

Technical and Scientific Impact

- Will provide an improved understanding of magnetostriction phenomenon and lead to the development of low cost compositions with low hysteresis, low saturation field, and good mechanical properties, and amenable to low cost conventional processing
- The technology developed will be used in numerous and rugged defense and commercial sensor and actuator applications including acoustic devices, MEMS devices, load sensors, anti-lock-braking systems, and structural systems for active damping of seismic waves

Significant Results

- A novel method for studying the influence of hydrogen on the magnetostriction of Fe alloys is being developed.
- Presence of H in FeGa alloys reduces their elastic modulus
- Magnetostrictions in numerous Fe-X (Sn, Ge, Si, Zn, Mo) and Fe-Ga-X (X=Al, Sn,Co,Ni,Ge,Si) alloys, prepared by directional solidification, have been examined.
- Substantial substitution of Ga with cheaper Al can be made in Fe-Ga alloys while retaining large magnetostriction. One of the optimal compositions has been identified.
- Single crystals of FeGa and other alloys have been prepared for detailed investigation



Plot of Magnetostrictive strain versus applied magnetic field showing large low field magnetostriction in directionally solidified FeGa alloys

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Training

- Three graduate students (Pinai Mungsantisuk, Purushottam Kumar and Robert Corson) are working towards their PhD.
- Undergraduate student Rebecca Chandler is studying the influence of ordering on magnetostriction.
- Participating students are trained in advanced processing and characterization techniques including single crystal growth, OIM in SEM, magnetic, magnetostriction, and elastic property measurements, Resonant Ultrasound Spectroscopy, and XRD
- Students in Physical Metallurgy, Magnetic Materials, and Materials Design courses were exposed to ongoing research and our research capabilities

Outreach Activities

- The PI and the graduate students showcased the Magnetic Materials Laboratory to about 50 high school students and parents during the Departmental Open-house
- Participated in the Innovation 2003 Showcase in Salt Lake City on May 19, 2003, which attracted nearly 300 visitors
- PI made an invited presentation on “Fe-based Low-Cost Magnetostrictive Alloys and Devices” at the Intl. Conf. “Advances in Materials & Processes for Industrial Applications & Materials Show 2003”, Pune, India in September, 2003.

Graduate student Pinai helping undergraduate Rebecca Cook with VSM measurements

Single crystal growth system built and used by graduate and undergraduate participants

High School Students and their parents visiting the Magnetic Materials Lab.

John Dougall, Utah State House of Representatives, at the MML booth during the “Innovation 2003 Showcase”

Visitors

- NSF Metals Program Director Dr. K.L. Murty visited our laboratory and presented a seminar on March 6, 2003.
- Dr. Brij Moudgil, Director, NSF Center on Particle Technology, University of Florida, visited the laboratory on April 18, 2003